

WE CLAIM AS OUR INVENTION:

1. An implantable heart stimulating device comprising:
 - a first pacing circuit connectable to a first pacing electrode, adapted to interact with a first ventricle of a heart, to allow said first pacing circuit to deliver pacing pulses via the first pacing electrode to pace the first ventricle;
 - a first sensing circuit connectable to a first sensing electrode, adapted to interact with the first ventricle, to transfer signals to the first sensing circuit to allow said first sensing circuit to sense said first ventricle;
 - a second pacing circuit connectable to a second pacing electrode, adapted to interact with a second ventricle of the heart, to allow said second pacing circuit to deliver pacing pulses via said second pacing electrode to pace the second ventricle;
 - a second sensing circuit connectable to a second sensing electrode, adapted to interact with the second ventricle, to transfer signals to said second sensing circuit to allow said second sensing circuit to sense said second ventricle; and
 - a control circuit that operates with time cycles corresponding to normal heart cycles, said control circuit operating with a first time delay to cause, within one of said time cycles, at least said first pacing circuit to pace the first ventricle or said first sensing circuit to sense the first ventricle, and to thereafter cause said second pacing circuit to deliver a pacing pulse to the second ventricle with said first time delay, said control circuit also operating with a criterion that characterizes a signal sensed by said first sensing circuit or said second sensing circuit, that satisfies said criterion, as a category of signals representative of premature

ventricular contraction, and said control circuit further operating with at least one of a second time delay and a third time delay for, within one of said time cycles, causing at least one of said first sensing circuit to sense the first ventricle and said second sensing circuit to sense the second ventricle, followed by delivery, if a predetermined pacing rule is satisfied, of a pacing pulse to the second ventricle, with said second time delay with said second pacing circuit, if the sensing was done by said first sensing circuit, or to deliver a pacing pulse to the first ventricle with said third time delay with said first pacing circuit if the sensing was done with said second sensing circuit.

2. An implantable heart stimulating device as claimed in claim 1 wherein said control circuit determines whether a signal sensed by the first or second sensing circuit is in said category and, if so, causes said first pacing circuit to deliver a pacing pulse to the first ventricle, in accordance with said predetermined pacing rule, if said signal in said category was sensed by said second sensing circuit, and to deliver a pacing pulse with said second pacing circuit to the second ventricle, in accordance with said predetermined pacing rule, if said signal in said category was sensed by said first sensing circuit.

3. An implantable heart stimulating device as claimed in claim 2 wherein said control circuit employs a rule as said predetermined pacing rule that causes said control circuit to cause said second passing circuit to deliver the pacing pulse to the second ventricle with said second time delay, if said signal in said category is sensed by said first sensing circuit.

4. An implantable heart stimulating device as claimed in claim 3 wherein said control circuit, if said signal in said category was sensed by said first sensing

circuit, thereafter monitors whether a corresponding signal is sensed by the second sensing circuit during said second time delay and, if so, said control circuit inhibits delivery of said pacing pulse with said second pacing circuit.

5. An implantable heart stimulating device as claimed in claim 2 wherein said control circuit employs a rule, as said predetermined pacing rule, that causes said control circuit to cause said first pacing circuit to deliver said pacing pulse to the first ventricle with said third time delay, if said signal in said category was sensed by said second sensing circuit.

6. An implantable heart stimulating device as claimed in claim 5 wherein said control circuit, if said signal in said category was sensed by said second sensing circuit, thereafter monitors whether a corresponding signal is sensed by the first sensing circuit during said third time delay and, if so, said control circuit inhibits delivery of said pacing pulse with said first pacing circuit.

7. An implantable heart-stimulating device as claimed in claim 1 wherein said control circuit employs delays, as each of said first, second and third time delays, that are shorter than 80 ms.

8. An implantable heart stimulating device as claimed in claim 1 wherein said control circuit employs a delay as said first time delay that is different from at least one of said second time delay and said third time delay.

9. An implantable heart stimulating device as claimed in claim 8 wherein said control circuit employs a delay, as said first time delay, that is longer than at least one of said second time delay and said third time delay.

10. An implantable heart-stimulating device as claimed in claim 1 wherein said control circuit employs a delay as said third time delay that is substantially equal to zero.

11. An implantable heart stimulating device as claimed in claim 1 further comprising a circuit arrangement adapted to interact with an atrium of the heart to sense and pace the atrium.

12. An implantable heart stimulating device as claimed in claim 11 wherein said control circuit employs a criterion, as said criterion for said category, that either a signal is sensed by the first sensing circuit after a previous sensed, paced or inhibited event relating to the first sensing circuit or the first pacing circuit, with no intervening sensed or paced event by the circuit arrangement for sensing and pacing the atrium, for that a signal is sensed by the second sensing circuit after a previous sensed, paced or inhibited event relating to said second sensing circuit or said second pacing circuit with no intervening sensed or paced event by said circuit arrangement for sensing and pacing the atrium.

13. An implantable heart stimulating system comprising:

- a first pacing electrode, adapted to be positioned to interact with a first ventricle of a heart;
- a first pacing circuit connected to said first pacing electrode to deliver pacing pulses via the first pacing electrode to pace the first ventricle;
- a first sensing electrode, adapted to be positioned to interact with the first ventricle;
- a first sensing circuit connected to said first sensing electrode to sense said first ventricle;
- a second pacing electrode, adapted to be positioned to interact with a second ventricle of the heart;

a second pacing circuit connected to said second pacing electrode to deliver pacing pulses via said second pacing electrode to pace the second ventricle;

a second sensing electrode, adapted to be positioned to interact with the second ventricle;

a second sensing circuit connected to said second sensing electrode to sense said second ventricle; and

a control circuit that operates with time cycles corresponding to normal heart cycles, said control circuit operating with a first time delay to cause, within one of said time cycles, at least said first pacing circuit to pace the first ventricle or said first sensing circuit to sense the first ventricle, and to thereafter cause said second pacing circuit to deliver a pacing pulse to the second ventricle with said first time delay, said control circuit also operating with a criterion that characterizes a signal sensed by said first sensing circuit or said second sensing circuit, that satisfies said criterion, as a category of signals representative of premature ventricular contraction, and said control circuit further operating with at least one of a second time delay and a third time delay for, within one of said time cycles, causing at least one of said first sensing circuit to sense the first ventricle and said second sensing circuit to sense the second ventricle, followed by delivery, if a predetermined pacing rule is satisfied, of a pacing pulse to the second ventricle, with said second time delay with said second pacing circuit, if the sensing was done by said first sensing circuit, or to deliver a pacing pulse to the first ventricle

with said third time delay with said first pacing circuit if the sensing was done with said second sensing circuit.

14. An implantable heart stimulating system as claimed in claim 13 wherein said control circuit determines whether a signal sensed by the first or second sensing circuit is in said category and, if so, causes said first pacing circuit to deliver a pacing pulse to the first ventricle, in accordance with said predetermined pacing rule, if said signal in said category was sensed by said second sensing circuit, and to deliver a pacing pulse with said second pacing circuit to the second ventricle, in accordance with said predetermined pacing rule, if said signal in said category was sensed by said first sensing circuit.

15. An implantable heart stimulating device as claimed in claim 14 wherein said control circuit employs a rule as said predetermined pacing rule that causes said control circuit to cause said second passing circuit to deliver the pacing pulse to the second ventricle with said second time delay, if said signal in said category is sensed by said first sensing circuit.

16. An implantable heart stimulating system as claimed in claim 15 wherein said control circuit, if said signal in said category was sensed by said first sensing circuit, thereafter monitors whether a corresponding signal is sensed by the second sensing circuit during said second time delay and, if so, said control circuit inhibits delivery of said pacing pulse with said second pacing circuit.

17. An implantable heart stimulating device as claimed in claim 14 wherein said control circuit employs a rule, as said predetermined pacing rule, that causes said control circuit to cause said first pacing circuit to deliver said pacing pulse to the first ventricle with said third time delay, if said signal in said category was sensed by said second sensing circuit.

18. An implantable heart stimulating system as claimed in claim 17 wherein said control circuit, if said signal in said category was sensed by said second sensing circuit, thereafter monitors whether a corresponding signal is sensed by the first sensing circuit during said third time delay and, if so, said control circuit inhibits delivery of said pacing pulse with said first pacing circuit.

19. An implantable heart stimulating system as claimed in claim 13 wherein said control circuit employs delays, as each of said first, second and third time delays, that are shorter than 80 ms.

20. An implantable heart stimulating system as claimed in claim 13 wherein said control circuit employs a delay as said first time delay that is different from at least one of said second time delay and said third time delay.

21. An implantable heart stimulating system as claimed in claim 20 wherein said control circuit employs a delay, as said first time delay, that is longer than at least one of said second time delay and said third time delay.

22. An implantable heart stimulating system as claimed in claim 13 wherein said control circuit employs a delay as said third time delay that is substantially equal to zero.

23. An implantable heart stimulating system as claimed in claim 13 further comprising a circuit arrangement adapted to interact with an atrium of the heart to sense and pace the atrium.

24. An implantable heart stimulating system as claimed in claim 23 wherein said control circuit employs a criterion, as said criterion for said category, that either a signal is sensed by the first sensing circuit after a previous sensed, paced or inhibited event relating to the first sensing circuit or the first pacing circuit, with no intervening sensed or paced event by the circuit arrangement for sensing and pacing

the atrium, for that a signal is sensed by the second sensing circuit after a previous sensed, paced or inhibited event relating to said second sensing circuit or said second pacing circuit with no intervening sensed or paced event by said circuit arrangement for sensing and pacing the atrium.

25. An implantable heart stimulating system as claimed in claim 13 wherein said first sensing electrode is a same electrode as said first pacing electrode, and wherein said second sensing electrode is a same electrode as said second pacing electrode.

26. An method for stimulating a heart comprising the steps of:
implanting and positioning a first pacing electrode to interact with a first ventricle of a heart;
connecting a first pacing circuit to said first pacing electrode to deliver pacing pulses via the first pacing electrode to pace the first ventricle;
implanting and positioning a first sensing electrode to interact with the first ventricle;
connecting a first sensing circuit to said first sensing electrode to sense said first ventricle;
implanting and positioning a second pacing electrode to interact with a second ventricle of the heart;
connecting a second pacing circuit to said second pacing electrode to deliver pacing pulses via said second pacing electrode to pace the second ventricle;
implanting and positioning a second sensing electrode to interact with the second ventricle;

connecting a second sensing circuit to said second sensing electrode to sense said second ventricle; and

controlling said first and second pacing circuits and said first and second sensing circuits with a control circuit that operates with time cycles corresponding to normal heart cycles, and with said control circuit causing, within one of said time cycles, at least said first pacing circuit to pace the first ventricle or said first sensing circuit to sense the first ventricle, and to thereafter cause said second pacing circuit to deliver a pacing pulse to the second ventricle with a first time delay, employing in said control circuit a criterion that characterizes a signal sensed by said first sensing circuit or said second sensing circuit, that satisfies said criterion, as a category of signals representative of premature ventricular contraction, and said control circuit, within one of said time cycles, causing at least one of said first sensing circuit to sense the first ventricle and said second sensing circuit to sense the second ventricle, followed by delivery, if a predetermined pacing rule is satisfied, of a pacing pulse to the second ventricle, with a second time delay with said second pacing circuit, if the sensing was done by said first sensing circuit, or to deliver a pacing pulse to the first ventricle with a third time delay with said first pacing circuit if the sensing was done with said second sensing circuit.

27. A method as claimed in claim 26 comprising, in said control circuit determining whether a signal sensed by the first or second sensing circuit is in said category and, if so, causing said first pacing circuit to deliver a pacing pulse to the first ventricle, in accordance with said predetermined pacing rule, if said signal in

said category was sensed by said second sensing circuit, and to deliver a pacing pulse with said second pacing circuit to the second ventricle, in accordance with said predetermined pacing rule, if said signal in said category was sensed by said first sensing circuit.

28. A method as claimed in claim 27 comprising, in said control circuit employing a rule as said predetermined pacing rule that causes said control circuit to cause said second pacing circuit to deliver the pacing pulse to the second ventricle with said second time delay, if said signal in said category is sensed by said first sensing circuit.

29. A method as claimed in claim 28 comprising in said control circuit, if said signal in said category was sensed by said first sensing circuit, thereafter monitoring whether a corresponding signal is sensed by the second sensing circuit during said second time delay and, if so, inhibiting delivery of said pacing pulse with said second pacing circuit.

30. A method as claimed in claim 27 comprising, in said control circuit employing a rule, as said predetermined pacing rule, that causes said control circuit to cause said first pacing circuit to deliver said pacing pulse to the first ventricle with said third time delay, if said signal in said category was sensed by said second sensing circuit.

31. A method as claimed in claim 30 comprising, in said control circuit, if said signal in said category was sensed by said second sensing circuit, thereafter monitoring whether a corresponding signal is sensed by the first sensing circuit during said third time delay and, if so, inhibiting delivery of said pacing pulse with said first pacing circuit.

32. A method as claimed in claim 26 comprising employing delays, as each of said first, second and third time delays, that are shorter than 80 ms.

33. A method as claimed in claim 26 comprising employing a delay as said first time delay that is different from at least one of said second time delay and said third time delay.

34. A method as claimed in claim 33 comprising employing a delay, as said first time delay, that is longer than at least one of said second time delay and said third time delay.

35. A method as claimed in claim 26 comprising employing a delay as said third time delay that is substantially equal to zero.

36. A method as claimed in claim 26 comprising implanting at least one atrial electrode in an atrium of the heart, and connecting a circuit arrangement to said atrial electrode and sensing and pacing the atrium with said circuit arrangement via said atrial electrode.

37. A method as claimed in claim 36 comprising employing a criterion, as said criterion for said category, that either a signal is sensed by the first sensing circuit after a previous sensed, paced or inhibited event relating to the first sensing circuit or the first pacing circuit, with no intervening sensed or paced event by the circuit arrangement for sensing and pacing the atrium, for that a signal is sensed by the second sensing circuit after a previous sensed, paced or inhibited event relating to said second sensing circuit or said second pacing circuit with no intervening sensed or paced event by said circuit arrangement for sensing and pacing the atrium.

38. A method as claimed in claim 26 comprising employing said at least one of said first and second time delays with values to allow reaction to said premature ventricular contraction to reduce an arrhythmia risk associated with the heart.

39. A method as claimed in claim 26 comprising implanting said first pacing electrode, said second pacing electrode, said first sensing electrode and said third sensing electrode in a living subject suffering from congestive heart failure.

40. A method as claimed in claim 26 comprising implanting said first pacing electrode, said second pacing electrode, said first sensing electrode and said third sensing electrode in a living subject suffering from a bundle branch block.